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Tire provided with a conductive loop and process for implanting this loop under its tread

Ins B1

The invention relates to a tire provided with a conductive loop and to a process for implanting such a loop, such as for example an inductive loop of a device for monitoring a tire in service.

In French Patent Application No. 97/07180, the Applicant has proposed a tire provided, in the vicinity of its tread, with a miniature sensor which detects the radial acceleration of the tire. Two loops, one mounted on the tire and the other on the vehicle, allow transfer of the information obtained to the vehicle. At least one other loop mounted on the vehicle allows the sensor and/or the electronic circuit which accompanies it in the tire to be supplied with power.

With regard to the construction of the loops, it is necessary to take into account the requirements associated with the current techniques in manufacturing tires, particularly radial-carcass tires, the complexity of which is known. In practice, the process for manufacturing such a tire comprises especially a step of stretching its carcass and a subsequent vulcanization treatment step in order to give it its

final shape. Thus, a conductive loop, as described in the aforementioned patent application, is implanted under the tire's tread, between these two steps. The process for manufacturing such a tire therefore requires an additional step of fastening this loop, something which may prove to be undesirable within the context of high-volume manufacture.

ins B2

The present invention aims to improve the situation.

For this purpose it provides a process for manufacturing a tire, in which the conductive loop is implanted before the step of stretching the carcass.

The invention therefore starts with a process comprising the following steps:

i - preparing a deformable preform for the carcass,

ii - holding this preform wound on a support of circular general shape,

iii - continuing the manufacture of the tire, in a manner known per se, with stretching of the preform thus held, in an outward general direction, after the fastening of its free ends.

According to the invention, step i) furthermore includes the preparation of a complementary preform comprising an elastic support, of rectangular general shape, homologous with that of the preform.

This elastic support is provided with at least one conductor fixed in a loose manner, also with a rectangular general shape.

Next, step ii) comprises holding this complementary preform and the aforementioned preform, on the support of circular general shape.

Thus, the process according to the invention makes it possible to implant at least one conductive loop or coil inside the tire without significantly modifying its manufacturing techniques.

This process is suitable equally well for the manufacture of a tire with a radial carcass, step i) including the preparation of a deformable preform for a radial carcass ply. The complementary preform is then held, during step ii), preferably between the two respective preforms for the radial carcass ply and for a sealing layer of the tire.

The subject of the invention is also a tire manufactured according to this process.

According to the invention, the tire then comprises, fixed under its tread, at least one conductive loop or coil which has, when opened out flat, a rectangular general shape. The short side and the long side of the rectangle extend substantially over the width of the tire and substantially all along

its periphery, respectively.

Ins B3

Further features and advantages of the invention will appear upon examining the detailed description below, and from the appended drawings in which:

- Figure 1 illustrates schematically the tire 1 according to the invention, provided with conductive loops B1 and B3 of a device for monitoring the state of the tire in service, in the example described;
- Figure 2 illustrates the complementary preform which includes the elastic support S and the conductive loop B1, placed between the respective preforms for the radial carcass ply 3 and the sealing layer 4;
- Figure 3a illustrates schematically the respective arrangements of the loop B1 and of the loop B2, which interact, in a front view;
- Figure 3b is a top view of the elements in Figure 3a;
- Figure 4 is a top view of the loop B1, opened out flat, on its support S;
- Figure 5 is a view on the section V-V in Figure 3a, showing some of the field lines which pass through the loops B1 and B2; and
- Figure 6 illustrates the equivalent circuit

diagram of the coupling between the two loops B1 and B2.

The drawings contain, mostly, elements of a certain character. They will therefore be able not only to serve to make the description more clearly understood, but also to contribute to the definition of the invention, as the case may be.

ins B4

Referring first of all to Figure 1, this shows a tire 1 with a radial carcass 3, mounted on the wheel of a motor vehicle in the example described, and provided with a sealing layer 4. The tire 1 is fitted with a first conductive loop B1 connected to an active element.

The active element comprises a miniature sensor 2 implanted under the radial carcass ply 3, near the tread. This sensor is designed to be sensitive to the radial acceleration that the rotation of the tire 1 induces. Thus, when part of the tread neighboring the sensor 2 is in contact with the ground, this part flattens and the sensor 2 undergoes a rectilinear movement. Said sensor then detects a sudden variation - particularly a reduction - in the radial acceleration that it undergoes, during the travel through a distance L (Figure 1) representative of the state of the tire.

The sensor may include, for example, a

piezoelectric material sensitive to the pressure that a mass m subjected to the centrifugal force exerts on it. This pressure can then be written as:

$$P = (m V^2) / (R S),$$

where m is the mass which undergoes the acceleration; V is the tangential velocity of the wheel; R is the radius of the wheel and S is the area of contact between the mass m and the piezoelectric material.

Thus, the time intervals during which the radial acceleration is zero, as well as their durations, representative of the state of the tire, are noted. When the sensor 2 is far from the ground, the piezoelectric material delivers a nonzero current. This information given by the sensor must be received and processed by processing means MT.

These processing means comprise especially a memory and an electronic circuit suitable for processing at least some of the measurements given by the sensor, and capable of writing data relating to these measurements into the memory.

However, such processing means cannot be completely incorporated into the tire 1. The sensor 2 is therefore connected to a first conductive loop B1 capable of interacting, by electromagnetic coupling, with a second loop B2 (data input/output), which is

connected to a part of the processing means MT. In practice, the nonvolatile memory (EEPROM) in the example is mounted in the tire, close to the sensor 2, and connected to the latter.

A magnetic flux is transmitted from the first induction loop B1 to the second induction loop B2. In order to improve the coupling between the induction loops B1 and B2, they are each connected to a capacitor C1 and C2 (Figure 6) so as to tune them to a band of frequencies near a central frequency w_1. In this case, the following equations are obtained:

$$L1.C1 \approx L2.C2 \approx 1/w_1^2,$$

where L1 and L2 are the inductances of the loops B1 and B2, and C1 and C2 are the capacitances of miniature capacitors connected to these loops, respectively.

Moreover, the active element includes an electronic or electrical circuit for amplifying the current output by the sensor 2. This circuit needs a supply, especially an electrical supply. The solution which would consist in implanting a battery mounted in the tire is not easily conceivable, given the treatment at high temperature (T ≈ 180°C) that the latter undergoes in order to cure the materials that it contains, after the stretching step. However, it should be noted that the Applicant has confirmed that the

components mounted with the loop B1, such as the sensor 2 or the miniature capacitor C1, withstand this treatment.

According to a more elaborate embodiment of the invention, the tire 1 may be fitted with a third conductive loop B3 suitable for interacting, by electromagnetic coupling, with a homologous loop B4 placed outside the tire and connected to external supply means MA. The amplification circuit of the active element is thus provided with greater autonomy. The loops B3 and B4 are each connected to a capacitor of capacitance chosen so that the loops B3 and B4 are tuned to a band of frequencies different from w_1, thereby making it possible to limit the perturbations normally induced in the coupling between the loops B1 and B2. The magnetic energy output by the loop B4 is recovered in the form of an electric current i flowing in the loop B3. The sensor 2 and its processing electronics have an intrinsic impedance z and can thus be supplied with an electrical voltage $V \approx z*i$.

The conductive loops are implanted in the tire, between the radial carcass ply 3 and the sealing layer 4 (Figure 2). During the aforementioned step i), a preform is therefore prepared which includes an elastic support S to which a conductor, shaped so as to

have the general shape of a rectangular open loop, is fixed. In practice, the conductive loop is immobilized between two plies of elastomer, preferably made of filled rubber. This step may furthermore include the fixing of another loop B3 (for the supply of the amplification circuit) to the elastic support, said other loop being homologous with this open loop B1.

The two loops are fixed to the support by a technique of the overcasting or tacking kind, the main point being that they are fixed in a loose manner in order to withstand the stretching of the preforms during step iii). Typically, the diameter of the tire reaches up to 150% of its initial value after this stretching step. The loops are then shaped in order to have initially, when opened out flat, more or less zigzagged lines (Figure 4). They preferably comprise insulated wires, which may be so-called Litz wires (known in the coils of long-wave and/or medium-wave amplitude-modulation radio sets). The ends of each loop (short sides of the rectangle) are joined during step ii) in order to be substantially adjacent. Thus, the induction effects at the ends cancel out.

Provision may be made to leave the two free ends of each loop visible in order to connect them to an active element and each end to at least one

miniature capacitor in order to improve the coupling, after either of steps ii) and iii).

Preferably, these connections are made during step i) so as to implant the active element under the preform for the radial carcass ply during step ii).

In practice, the loop B1 is in the form of a coil having about ten turns. The sensor 2 and the miniature capacitor C1 are produced by integrated technology and have substantially the same thickness as the loop B1 (approximately 2 mm) so as to be housed in the tire without a local additional thickness, a difference in thickness being compensated for by a covering ply of the tire (approximately 1 mm on each side of the support band S).

According to the invention, the two loops have, when flat, a more or less rectangular shape, the short side and the long side of the rectangle extending substantially over the width of the tire and along its periphery, respectively.

To optimize the coupling between the loops B1 and B2 on the one hand and B3 and B4 on the other, the loops B2 and B4 placed outside the tire also have a more or less rectangular shape. In the French patent application cited in the introduction, the loops B2 and B4 of the monitoring device were placed in a plane

perpendicular to the "plane" of the loops B1 and B3 (the plane of Figure 3b). The electromagnetic coupling between the loops is, in such an arrangement, particularly sensitive to the movements of the suspension. In the embodiment proposed by the present application, the loops B2 and B4 are placed on a wheel arch (or fender) of the vehicle near the loops B1 and B3. The long side of the rectangle that they form when flat extends over a circular arc concentric with the radial carcass 3 of the tire. Thus, the distance d between the loops placed in the tire and on the vehicle is approximately constant at rest (Figure 3a).

However, this distance may vary depending on the movements of the suspension. The Applicant has consequently provided loop widths of the same order of magnitude as the distance d; a slight deviation in this distance does not generate an appreciable variation in the magnetic flux transmitted between the loops.

Moreover, the loops mounted on the vehicle are slightly wider than those implanted in the tire. Thus, the field lines H (Figure 5) may pass within the loops without the transmission of the magnetic flux being perturbed by any turning angle that the wheel would adopt with respect to the axis of the vehicle.

Typically, the inter-loop coupling losses in

the example described amount to approximately 20 dB, whereas they would be around 30 dB in the configuration described in the aforementioned patent application.

Of course, the invention is not limited to the embodiment described above by way of example, it extends to other variants.

Thus, it will be understood that the tire according to the invention may include only a single induction loop B1 allowing the active element to be connected to processing means MT, as well as to supply means MA. In this case, the loop B1 may interact with the supply loop B4 over a band of frequencies close to w_1 (typically 40 kHz). By modulating the return carrier, the loop B1 may interact with the loop B2 connected to the processing means MT over a band of frequencies close to a frequency w_2, which is a multiple of the frequency w_1 (for example, w_2 = 80 kHz).

In the configuration described in the example, the loops are implanted under the radial carcass ply, which assumes that the metal structure of the carcass can induce perturbations on the transmitted fluxes. However, the Applicant has found that the coupling losses do not increase significantly in the configuration described.

In general, the invention allows electrical

communication (in the wide sense) right to the supply between a tire and the chassis of a vehicle. It is particularly applicable to detecting the state of a tire by measuring the acceleration. It is capable of many variants, especially with regard to the data transmitted and to the physical magnitude which serves for detecting the state of the tire.